ENRICHMENT OF HEAVY METAL AND RISK ASSESSMENT IN SURFACE WATER OF TUNGGAK RIVER, GEBENG, PAHANG

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ABSTRACT

Surface water includes all water on surface of the earth that can be found in rivers, streams, canals, lakes, wetlands, coastal, ditches, marshes and ponds waters and also appears as in ice and snow. Industrial activities are the main cause for surface water pollution. Therefore, the objectives of this research were to evaluate the enrichment factor of heavy metal from the surface water and to provide the latest level of water pollution in Tunggak River. To fulfil it, several water quality parameters were analyzed, with collection of data from 3 different stations during February-March 2015 across the river basin. The in-situ parameters were temperature, pH, turbidity, Electric Conductivity and Dissolved Oxygen. Meanwhile, for ex-situ parameters such as Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids, Ammoniacal Nitrogen and selected heavy metal, analysis were conducted by using DR/2500 Spectrophotometer and Atomic Absorption Spectrometer using APHA and HACH standard methods. Later, the results from all the tests were used to calculate the Enrichment Factor, National Water Quality Standard and Water Quality Index to indicate the quality of the study area. The study revealed that some trace metals were found in surface water of the Tunggak River, Gebeng, most probably caused by the industrial activities and the availability of numerous of factories surrounded the river. From the results, the authorities should implement the suitable watershed protection and management system to control the pollution of the surface water.

ABSTRAK

Air di permukaan termasuk semua air di permukaan bumi ini yang boleh didapati di sungai, anak sungai, terusan, tasik, tanah paya, pantai, longkang, paya dan kolam dan juga terdapat dalam ais dan salji. Aktiviti perindustrian adalah punca utama pencemaran air di permukaan. Oleh itu, objektif kajian ini adalah untuk menilai faktor pengayaan logam berat daripada air di permukaan dan untuk menyediakan tahap terkini pencemaran air di Sungai Tunggak. Untuk melaksanakannya, beberapa parameter kualiti air telah dianalisis, pungutan data dari 3 stesen yang berbeza dalam bulan Februari hingga Mac 2015 di seluruh lembangan sungai. Parameter in-situ adalah suhu, pH, kekeruhan, Electric kekonduksian dan oksigen terlarut. Sementara itu, bagi parameter ex-situ seperti Permintaan Oksigen Biokimia, Permintaan Oksigen Kimia, Jumlah Pepejal Terampai, Ammoniakal Nitrogen dan logam berat terpilih, analisis telah dijalankan dengan menggunakan DR / 2500 Spectrophotometer dan Penyerapan Spektrometer Atom menggunakan APHA dan Hach kaedah standard. Kemudian, keputusan daripada semua ujian telah digunakan untuk mengira Factor Pengayaan, National Standard Kualiti Air dan Indeks Kualiti Air untuk menunjukkan kualiti kawasan kajian. Kajian ini mendedahkan bahawa sesetengah logam surih ditemui dalam air di permukaan Sungai Tunggak, Gebeng, kemungkinan besar disebabkan oleh aktiviti perindustrian dan ketersediaan banyak kilang-kilang yang dikelilingi sungai. Daripada keputusan, pihak berkuasa perlu melaksanakan perlindungan kawasan tadahan air dan pengurusan sistem yang sesuai untuk mengawal pencemaran air permukaan.

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LIST OF SYMBOLS

˚C	Degree Celsius
mg/L	milligram per meter
NTU	Nephelometric Turbidity Unit
%	Percent
ppm	parts-per-million
µS/cm	micro-Siemens per centimeter
mS/cm	milli-Siemens per centimeter

LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrometer
AN	Ammoniacal Nitrogen
As	Arsenic
Ba	Barium
BOD_5	Biochemical Oxygen Demand (5 days)
Cd	Cadmium
Co	Cobalt
Cr	Chromium
Cu	Copper
DO	Dissolved Oxygen
EC	Electrical Conductivity
EF	Enrichment Factor
Hg	Mercury
Ni	Nickel
NWQS	National Water Quality Standards
Pb	Lead
TSS	Total Suspended Solids
WQI	Water Quality Index
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Surface water includes all water on surface of the earth that can be found in rivers, streams, canals, lakes, wetlands, coastal, ditches, marshes, ponds and marine waters and also appears as in ice and snow. The water of the sea and ocean are excluded to be considered in surface water due to its definition of fresh water. Generally, surface water is well aerated because it condition of water-atmosphere interface. The pollution of the surface runoff in particular mostly contains high level of heavy metals and other harming substances such as nitrogen and phosphorus that had increased the level of contaminants. If surface water pollution sources are derived from groundwater or runoff water from upland soil, the pollutants will directly enter the surface water body over a large area. This shows that the pollutant sources for the surface water diffuse either from the soil surface or groundwater. For the study area, Tunggak River at Gebeng Pahang, the pollutant probably may come from the effluent of industrial and municipal wastewater. The effluents will not only rich in pathogenic bacteria and viruses, organic matter and nutrients, but may also enriched with level of heavy metals.

Zinc, Lead and Copper are the examples of element for the group of heavy metal that always been related with the contamination and the potential toxicity toward environment especially to the surface water. Heavy metal either can be define as a metal with atomic mass that bigger than Sodium or as it have metal density with range of 3.5 – 6.0 g cm^{-3}. Non-industrial human usually find the involvement of the heavy metals dissolved in water, sorbed

in the soil or contained in foods. Mostly, heavy metals present as cations in the environment and would occurs naturally in the Earth's crust impurities isomorphously substituted for various macro element constituents in the lattices of many primary and secondary minerals.

1.2 OBJECTIVES OF RESEACRH

There are two main objectives for these research:

a) To determine the pollution level of surface water quality in the Tunggak River, Gebeng , Pahang.
b) To assess the environment risk of heavy metal contaminations in surface water based on the Enrichment Factor.

1.3 PROBLEM STATEMENT

The diffusion of heavy metal into the surface sediment of the soil would directly affect the nearest surface water such as effluent from industrial site. This phenomenon which happened since long time ago probably had affected not only human's health but also the ecosystem cycle.

a) The industrial discharge (anthropogenic sources of heavy metal) cause to pose further toxic towards the aquatic life.
b) The enrichment of heavy metal for a long time from the industrial effluent causing it to accumulated to the environment in various ways.
c) This studies is carried out to monitor the heavy metal contaminations in the surface water of the Tunggak River at Gebeng, Pahang based on the Enrichment Factor.
d) The research is carried out to evaluate the level of pollution of the Tunggak River at Gebeng, Pahang.

1.4 SCOPE OF RESEARCH

The study is conducted at Tunggak River, Pahang that near to Gebeng industrial area. Tunggak River is a class H stream (Hydrographic) in Malaysia with Asia Pacific region font code. This stream located at Pahang with coordinate 3°57'0"N and 103°22'1"E or 3.95 and 103.367 in decimal degrees. The effluent discharges from numerous industrial sites either it's been treated or untreated is flowing out to the river carrying together the wastewater that may be contains various of substances that probably will increase the contamination level such as organic compounds, phosphorus, nitrogen and heavy metal. This study will carried out by taking the samples from three points at the three different and nearest effluent by the industrial activities at the river. The samples will be test by several of parameters in order to achieve the objectives of this research.

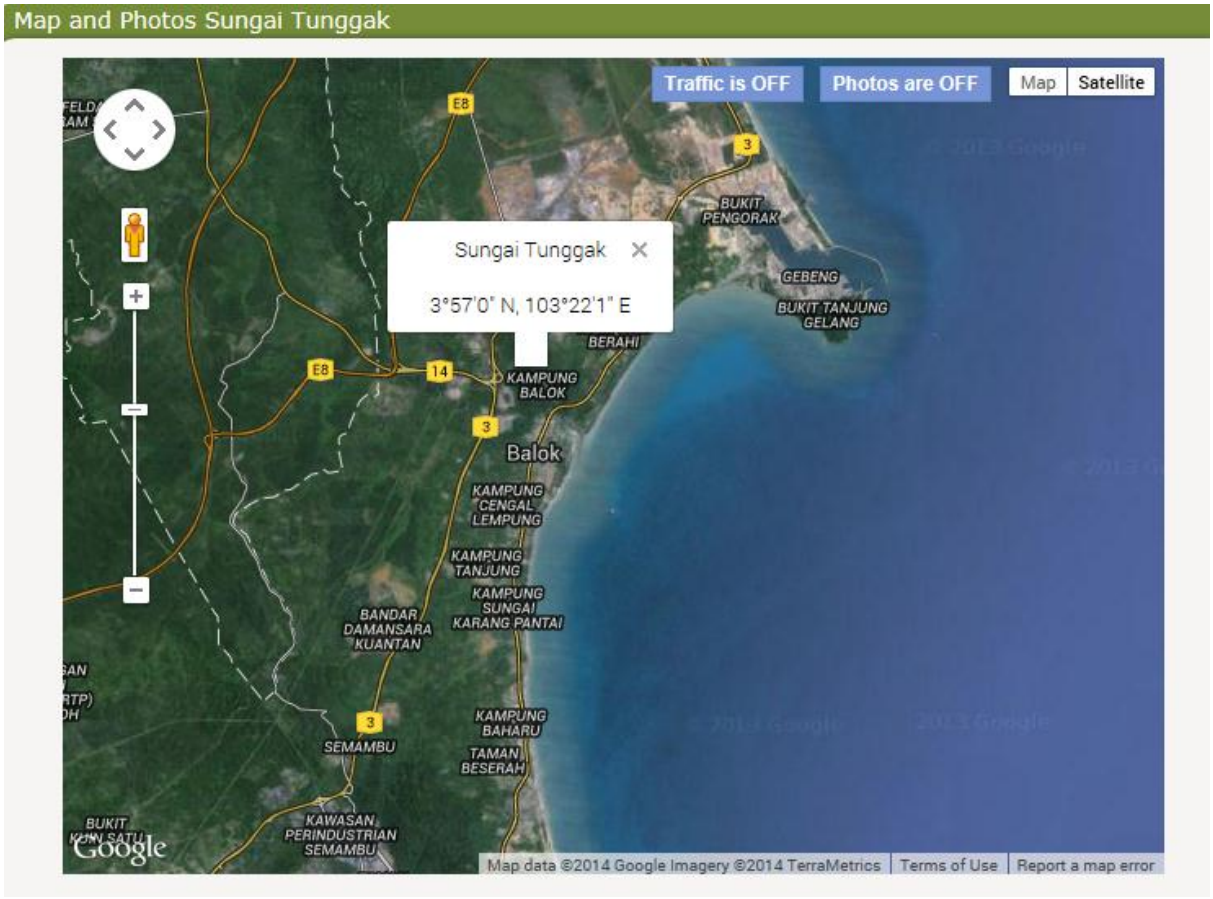

Figure 1.1: Location of Tunggak River.

1.5 SIGNIFICANT OF RESEARCH

This study is carried out to evaluate the enrichment of heavy metal and risk assessment in surface water at Tunggak River, Pahang, Malaysia in order to determine the pollution level and the environmental risk from the contamination of heavy metal around that area. The sample of surface water taking from there must be the effluent wastewater either being treated or treated that are flowing out to the Tunggak River.

Generally, every effluent that flows out from industrial area may contains several of harmful substances such as high level of heavy metal diffused from the contaminated soil and also nitrogen and phosphorus. A considerable stock of pollutants may accumulate over the years and finally concentrates towards the surface water. This phenomenon may be really dangerous for human and also the aquatic life because there will be many bad effects towards them due to there are the majority usage of this surface water.

So, the significance of this research would be to provide the latest level of water pollution so that the suitable and efficient ways of the wastewater treatment can be done to this area. It is important to the residents that depends on this source to have a clean and unpolluted water to be used in their daily life. Besides, by having this research, the rate of enrichment factors of the heavy metal that been concentrated inside the surface water will be acknowledged. So, the further research on how to decrease the level of harmful substances inside the water can be done in the future for the sake of our ecosystem.

1.6 EXPECTED OUTCOMES

There are some of expected results to be encountered from this study:

a) The level of water pollution getting from experiments for the sample taken from Tunggak River, Pahang, Malaysia.
b) The enrichment and the assessment rate of heavy metal at the surface water by using Enrichment Factor to test their concentration at the water for years.
c) The risk that the residents near the river the aquatic life faced from the pollution that happened.

CHAPTER 2

LITERATURE REVIEW

2.1 SURFACE WATER POLLUTION

Similar to other water resources, surface water is considered the main source of available water which is polluting all over the world in many ways. One of the main activities that causes the pollution is known as Anthropogenic. The development of industries and their effluents are the major threats to the surface water which become the last destination for the effluents (Moorthy and Jeyabalan, 2012). Besides, the economy trend that increasing rapidly nowadays in Malaysia make the pollution become worst and causes the environmental degradation (Tan and Yap, 2006; Al-Shami et al. 2011). At the same time, the rivers are contributing significantly for the industrial development in Malaysia (Moorthy and Jeyabalan, 2012). So, the surface water pollution can cause serious health risk as well as environmental threats in the country. The major sources of industrial pollution in Malaysia are food & beverage, chemical & petrochemical, palm oil, textile, paper and rubber processing industries (Iyagba et al., 2008). Speedy growth in industrial sector generates more wastes which could damage to the environment without having proper treatment plant. Industrialization with an increasing demand for heavy metals results in a high emission of these pollutants into the biosphere. Water bodies with heavy metal pollution are a serious threat to the aquatic ecosystem, human health as well as environment (Hossain and Sujaul, 2012).

2.2 CONTAMINATION OF HEAVY METAL IN SURFACE WATER

Metal have been used by human beings for more than 10000 years. As an example, copper had been used around 7000-9000 years ago after being found by Ali Kosh at Western Iran and Cayo nu Tepesi near Ergani in Anatolia (Chen.J.P, 2012). Heavy metal is also be known as the group of metals and metalloids with atomic density greater than 5 g/cm^3 and having molecular weight with 40 and above. There are several common characteristics that can be relate with heavy metal:-

a) A good conductor of electricity
b) An electric resistance of a metal that directly proportional to the absolute temperature
c) Is the high thermal conductivity
d) Has malleability and ductility, without which cannot be drawn into sheets and wires
e) Valence or oxidation number as 0, +1, +2, +3 and also +6
f) Zero-valent metal is present in solid form except for Mercury
g) Exist in nature as metal oxides, metal carbonate or metal sulfate

Differ from any ordinary pollutants that able to be degraded for detoxification, heavy metal unfortunately will become harmful and products towards environment. Due to that causes, many countries desperately need to get through this problem either in developed countries or in developing countries especially China that leading in importer of metal ores and products. Construction, electronic and chemical industries are the main consumers of heavy metal contaminations at the stream and surface water.

2.2.1 Copper

Copper is a one of element of heavy metal not only exists in the environment as a mineral in rocks and soil but also can be easily found in natural water resources and human bodies. It is also an element that enable to maintain human's good health by supporting the hemoglobin production for red blood cells in human's circulation system. By this process, the enzymes getting from copper will helps to carry oxygen throughout the body thus, let the tendons and cartilage become stronger. In industrial field, copper are used for piping and plumbing systems at many countries worldwide.

However, once the copper start to corrode, it may cause many problems towards the environment. While the corrosion occur, the potable water resources may be affected due to its safety and quality. Approximately, only 2 to 3 milligrams of copper can be consumed by an adult. If copper being consume in excessive amount, it may be harmed for human an causes for vomiting, nausea, headache and gastric complaints or even causes of liver damage and finally death.

2.2.2 Lead

Lead or written as Pb is an element from carbon group that also be known as Plumbum in Latin. Having atomic number of 82, lead is a metal that is soft, malleable and heavy post-transition metal. The physical appearance is that it has a bluish-white color after being freshly cut, but will be change to a dull grayish color when exposed to air. It also will become a shiny chrome-silver luster when it is melted into a liquid. It is also the heaviest non-radioactive element.

In industrial purposes, lead is used in building construction, lead-acid batteries, bullets and shot, weights, as part of solders, pewters, fusible alloys, and as a radiation shield. Lead accumulates in the bodies of water organisms and soil organisms. These will experience health effects from lead poisoning. Health effects on shellfish can take place even when only very small concentrations of lead are present. Body functions of phytoplankton can be disturbed when lead interferes. Phytoplankton is an important source of oxygen production in

seas and many larger sea-animals eat it. That is why we now begin to wonder whether lead pollution can influence global balances.

2.2.3 Zinc

Zinc is a metal. It is called an “essential trace element” because very small amounts of zinc are necessary for human health. It is also used for boosting the immune system, treating the common cold and recurrent ear infections, and preventing lower respiratory infections. It is also used for malaria and other diseases caused by parasites.

Zinc is used to make many useful alloys. Brass, an alloy of zinc that contains between 55% and 95% copper, is probably the best known zinc alloy. Brass was first used about 2,500 years ago and was widely used by the ancient Romans, who used it to make such things as coins, kettles and decorative items. Brass is still used today, particularly in musical instruments, screws and other hardware that must resist corrosion. Zinc is alloyed with lead and tin to make solder, a metal with a relatively low melting point used to join electrical components, pipes and other metallic items. Prestal®, an alloy containing 78% zinc and 22% aluminum, is a strange material that is nearly as strong as steel but is molded as easily as plastic. Nickel silver, typewriter metal, spring brass and German silver are other common zinc alloys.

2.2.4 Arsenic

Arsenic appears in three allotropic forms: yellow, black and grey; the stable form is a silver-gray, brittle crystalline solid. It tarnishes rapidly in air, and at high temperatures burns forming a white cloud of arsenic trioxide. Arsenic is a member of group Va of the periodic table, which combines readily with many elements.

The metallic form is brittle, tarnishes and when heated it rapidly oxidizes to arsenic trioxide, which has a garlic odor. The non-metallic form is less reactive but will dissolve when heated with strong oxidizing acids and alkalis.

The arsenic cycle has broadened as a consequence of human interference and due to this, large amounts of arsenic end up in the environment and in living organisms. Arsenic is mainly emitted by the copper producing industries, but also during lead and zinc production and in agriculture. It cannot be destroyed once it has entered the environment, so that the amounts that we add can spread and cause health effects to humans and animals on many locations on earth.

Plants absorb arsenic fairly easily, so that high-ranking concentrations may be present in food. The concentrations of the dangerous inorganic arsenics that are currently present in surface waters enhance the chances of alteration of genetic materials of fish. This is mainly caused by accumulation of arsenic in the bodies of plant-eating freshwater organisms. Birds eat the fish that already contain eminent amounts of arsenic and will die as a result of arsenic poisoning as the fish is decomposed in their bodies.

2.2.5 Chromium

Chromium is a lustrous, brittle, hard metal. Its color is silver-gray and it can be highly polished. It does not tarnish in air, when heated it burns and forms the green chromic oxide. Chromium is unstable in oxygen, it immediately produces a thin oxide layer that is impermeable to oxygen and protects the metal below.

Chromium main uses are in alloys such as stainless steel, in chrome plating and in metal ceramics. Chromium plating was once widely used to give steel a polished silvery mirror coating. Chromium is used in metallurgy to impart corrosion resistance and a shiny finish; as dyes and paints, its salts color glass an emerald green and it is used to produce synthetic rubies; as a catalyst in dyeing and in the tanning of leather; to make molds for the firing of bricks. Chromium (IV) oxide (CrO_2) is used to manufacture magnetic tape.

There are several different kinds of chromium that differ in their effects upon organisms. Chromium enters the air, water and soil in the chromium (III) and chromium (VI) form through natural processes and human activities.

2.2.6 Cadmium

Cadmium is a lustrous, silver-white, ductile, very malleable metal. Its surface has a bluish tinge and the metal is soft enough to be cut with a knife, but it tarnishes in air. It is soluble in acids but not in alkalis. It is similar in many respects to zinc but it forms more complex compounds.

About three-fourths of cadmium is used in Ni-Cd batteries, most of the remaining one-fourth is used mainly for pigments, coatings and plating, and as stabilizers for plastics. Cadmium has been used particularly to electroplate steel where a film of cadmium only 0.05 mm thick will provide complete protection against the sea. Cadmium has the ability to absorb neutrons, so it is used as a barrier to control nuclear fission.

Cadmium waste streams from the industries mainly end up in soils. The causes of these waste streams are for instance zinc production, phosphate ore implication and bio industrial manure. Cadmium waste streams may also enter the air through (household) waste combustion and burning of fossil fuels. Because of regulations only little cadmium now enters the water through disposal of wastewater from households or industries.

2.2.7 Cobalt

Cobalt is a hard ferromagnetic, silver-white, hard, lustrous, brittle element. It is a member of group VIII of the periodic table. Like iron, it can be magnetized. It is similar to iron and nickel in its physical properties. The element is active chemically, forming many compounds. Cobalt is stable in air and unaffected by water, but is slowly attacked by dilute acids.

Most of the Earth's cobalt is in its core. Cobalt is of relatively low abundance in the Earth's crust and in natural waters, from which it is precipitated as the highly insoluble cobalt sulfine (CoS). Although the average level of cobalt in soils is 8 ppm, there are soils with as little as 0.1 ppm and others with as much as 70 ppm. In the marine environment cobalt is needed by blue-green algae (cyanobacteria) and other nitrogen fixing organisms. Cobalt is not found as a free metal and is generally found in the form of ores. Cobalt is usually not

mined alone, and tends to be produced Cobalt is an element that occurs naturally in the environment in air, water, soil, rocks, plants and animals. It may also enter air and water and settle on land through wind-blown dust and enter surface water through run-off when rainwater runs through soil and rock containing cobalt.

2.2.8 Barium

Barium is a silvery-white metal that can be found in the environment, where it exists naturally. It occurs combined with other chemicals, such as sulfur, carbon or oxygen. Ii is very light and its density is half that of iron. Barium oxidizes in air, reacts vigorously with water to form the hydroxide, liberating hydrogen. Barium reacts with almost all the non-metals, forming often poisoning compounds.

Barium is surprisingly abundant in the Earth's crust, being the 14th most abundant element. High amounts of barium may only be found in soils and in food, such as nuts, seaweed, fish and certain plants. Because of the extensive use of barium in the industries human activities add greatly to the release of barium in the environment. As a result barium concentrations in air, water and soil may be higher than naturally occurring concentrations on many locations.

Some barium compounds that are released during industrial processes dissolve easily in water and are found in lakes, rivers, and streams. Because of their water-solubility these barium compounds can spread over great distances. When fish and other aquatic organisms absorb the barium compounds, barium will accumulate in their bodies. Because it forms insoluble salts with other common components of the environment, such as carbonate and sulphate, barium is not mobile and poses little risk. Barium compounds that are persistent usually remain in soil surfaces, or in the sediment of water soils. Barium is found in most land soils at low levels. These levels may be higher at hazardous waste and water sites.